FREQUENCY DISTRIBUTION OF NUMBERS OF PERENNIAL SHRUBS IN THE NORTHERN MOJAVE DESERT

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ABSTRACT.— Frequency distribution according to plant size as measured by dimensional analysis on different mathematical bases were determined for 10 common perennial plant species from Rock Valley in the northern Mojave Desert in Nevada. A total of 4282 individual plants was measured. The data provide information concerning the stability and prosperity of the natural vegetation as judged by the relative proportions of individuals in the size-class spectrum, as well as show graphically the relative abundance of the different species in the study area.

On the species level, the populations were close to normally distributed on the $\log_e$ basis, but with remarkably negative skewness due to better segregation of the small-sized individuals into many segmental units. On the arithmetic basis, three categories of frequency pattern were recognized, but all with marked positive skewness due to better segregation of large-sized individuals into many segmental units.

The feature common to all species studied is the preponderance of young individuals, which in many cases could have an abundance many times that of large individuals. The natural vegetation in Rock Valley, therefore, represents a reasonably active stage.

Assembling and comparing observations on the size classes of the component species of the natural vegetation are of primary concern for understanding the stability and prosperity of the vegetational cover. The size-class spectrum may also reveal valuable information in relation to climatic features occurring in the past during the early life of the existing vegetation, as well as the possible segregation of the individual species into two or more ecotypes.

The purpose of this study is to demonstrate through two different mathematical approaches the size-class frequency distribution for 10 common perennial species in the Rock Valley area of the northern Mojave Desert. The site involved and the original data obtained are part of the US/IBP Desert Biome studies.

Material and Methods

A system random-number-generating function (Wallace and Romney 1972) was used to select the random number pairs whose intersection identify sample location within the study area. A total of 4282 randomly selected individuals from 190 sampling plots (50×2 m) have been considered. The sampling technique was designed so that sampling points could be randomly distributed over the entire area. Each individual was identified by species and measured for height and width (mean of dimension) in 1971 at the Rock Valley IBP validation site. Calculations using these dimensional measurements were made to estimate shrub biomass, using previously calculated regression equations of dry weight on volume indices for the different species investigated (Wallace and Romney 1972).

Frequency for size-class distributions were made for shoot weights on arithmetic and $\log_e$ bases. A computer program was developed in which the class interval on the X axis and the scale of abundance on the Y axis were kept constant for all species, when data were illustrated on the $\log_e$ basis. In the arithmetically illustrated data, the scale on both Y and X axes varies from one species to the other.

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Results and Discussion

The results of the size-class distribution on the $\log_e$ basis are illustrated graphically in Figure 1. The frequency distribution for all species is close to normal, with some negative skewness, the degree of which differs from

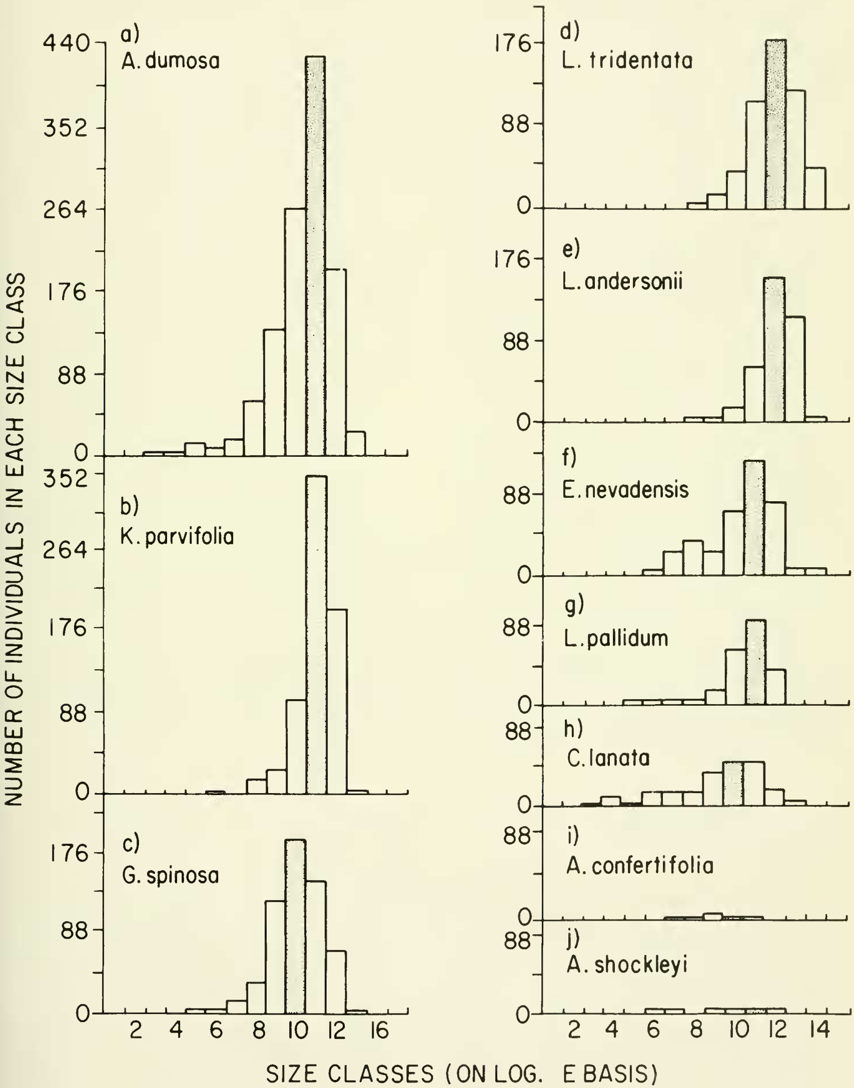

Fig. 1. Size distribution of 10 shrubs based on stem dry weights. Size-class interval is constant for all species (975 g). Shaded bars represent size classes with individuals that are close to the average weight for the species.

one species to the other. This negative skewness is attributed to the fact that the transformation of data into natural log values has resulted in a better segregation of small-sized individuals into many classes. This can be readily observed when examining the number of size classes on both sides of that class representing those individuals with an average weight.

The abundance of the different species, as reflected by their absolute frequencies (which represent one aspect of the species importance), is given in Table 1 and can also be easily detected from Figure 1. *Ambrosia dumosa* (A. Gray) Payne is the most frequent species in the study area. It has been randomly recorded 1183 times out of 4282 records for all species. The species poorly represented are those of *Atriplex confertifolia* (Torr. & Frem.) Wats. and *Acamptopappus shockleyi* Gray, represented by 37 and 23 individuals, respectively.

Another point of interest is the fact that all species exhibit large standard deviation (Table I) relative to the means. This is particularly remarkable for *A. dumosa*, *Larrea tridentata* (Sesse & Moc. ex DC.) Cov., *Lycium pallidum* Miers, and *A. shockleyi*. The standard deviation for these species exceeds the mean weights.

The relation between size classes and the total number of individuals, irrespective of their taxonomic position, is given in Table 2. Examination of these data shows that size class 11 with log. ranging from 4.169 to 5.144 (arithmetic range from 64.63 to 171.4 g/plant) embraces the higher number of individuals (1,361 out of 4,282). In this class, *A. dumosa*, *Krameria parvifolia* Benth., *Ephedra nevadensis* Wats., and *A. confertifolia* attain their maximum abundance. On either side of this class the number of individuals progressively decreases.

The preponderance of younger individuals, as reflected in Figure 1, is an indication of vitality and prosperity of the species; it is mostly due to successful germination of seeds and survival of seedlings. Rainfall in the year 1969 was above normal and may be the source of the seedlings observed.

The size-class frequency distribution on the arithmetic basis shows another interesting picture. Figure 2 shows the frequency distribution for three representative shrubs, each with its specific pattern. Three shapes of frequency distribution have been recognized; the j-shape, asymmetric, unimodal, positively skewed shape, and the asymmetric, polymodal shape. Categorizations of the 10 species studied according to the shape of their frequency distribution are given in Table 3. It is obvious that seven species belong to category (a), i.e., with a J-shape distribution. These species are *L. tridentata*, *A. dumosa*, *Grayia spinosa*, *E. nevadensis*, *Ceratoides lanata* (Pursh) J. T. Howell, *L. pallidum*, and *A. confertifolia*. A similar pattern of size-class distribution for *L. tridentata* has been previously demonstrated by Chew and Chew (1965). In category (b) the representative species are *K. parvifolia* and *L. andersonii*. Category (c) is represented by *A. shockleyi*.

TABLE 1. Some statistical attributes reflecting abundance and distribution of total stem weights (g) of ten Rock Valley shrubs (of 4282 randomly selected plants).

Species	No. of individuals	Mean weight of stem g/plant	Standard dev. g/plant	Maximum g/plant	Minimum g/plant	Range g/plant
Ambrosia dumosa	1183	108.7	111.0	952.6	0.1	952.5
Krameria parvifolia	732	136.4	96.9	682.6	1.0	681.6
Grayia spinosa	591	74.3	85.8	716.0	0.3	715.7
Larrea tridentata	517	437.9	454.1	3164.0	<0.1	3164.0
Ephedra nevadensis	387	119.1	202.9	2878.0	0.7	2877.0
Lycium andersonii	351	371.4	266.3	1470.0	8.2	1462.0
Ceratoides lanata	234	62.7	96.9	640.9	<0.1	640.9
Lycium pallidum	227	264.4	216.4	1041.0	1.2	1040.0
Atriplex confertifolia	37	33.7	32.8	107.2	2.1	105.2
Acamptopappus shockleyi	23	68.3	82.8	371.8	0.9	370.9

It should be mentioned, however, that the lack of unified scale (in all species) either on the X or Y axes for this type of mathematical representation of frequency distribution makes it impossible to draw quick comparison between species, particularly with regard to their abundance. However, it is clear from Figure 2 that, in contrast to Figure 1, the skewness is positive, which is an indication of better segregation of the large-sized individuals into more segmental units. Accordingly, the two approaches applied for the frequency distribution are rather useful and complementary.

The discontinuity represented in Figure 2 for *A. shockleyi* might indicate that the input of new seedlings of *A. shockleyi* in the ecosystem is not a steady process, but rather is affected by the prevailing environmental variables, particularly rainfall. However, the fact that this species is represented in this survey by relatively few individuals makes it difficult to explain precisely the causal factors behind its asymmetric polymodal frequency distribution.

A point of interest is that in these types of grouped frequency distributions the degree of skewness and even its sign are rather artifacts and are controlled by the scale of class interval. Accordingly, these two parameters cannot be considered as 100 percent reliable tools for reflecting the rate of new seedlings input (in a given ecosystem) versus the rate of loss of old individuals. More reliable information might be gained through comparing the actual number of individuals in the different size classes on either side of the average class and the rate of their input and loss. The fact that grouped frequency distributions, in contrast to regular frequency distributions, sacrifice some information for convenience by combining several score values in a single class interval has been reported by Welkowitz et al. (1971).

Another interesting point is the fact that a bimodal distribution often indicates that two major kinds of cases are concealed within the one distribution. In the present study the possibility of the presence of two or more ecotypes of a given specific population might be one of the causal factors for the presence of polymodal frequency distribution. Whether or not *A. shockleyi* consists of different ecotypes needs further detailed investigation, however. The possibility of the presence of two distinct ecotypes of *L. tridentata* in Rock Valley that differ on the basis of size and leaf characteristics has been previously reported by Wallace and Romney (1972). In the present set of data, the segregation of *L. triden-*

TABLE 2. Pooled distribution of individuals of 10 species in 15 size-classes (g per plant). The size classes that contain the most individuals of each species is identified.

Size	$\log_e$ range	Arithmetic range	Total no. of individuals	Maximum abundance size classes for the species
1	< -4.606	< 0.01	—	
2	-4.606 to -3.507	0.01 to 0.03	1	
3	-3.507 to -2.659	0.03 to 0.07	7	
4	-2.655 to -1.561	0.07 to 0.21	14	
5	-1.561 to -0.713	0.21 to 0.49	22	
6	-0.713 to 0.270	0.49 to 1.31	43	
7	0.270 to 1.244	1.31 to 3.47	91	
8	1.244 to 2.219	3.47 to 9.2	182	
9	2.219 to 3.194	9.2 to 24.39	399	
10	2.194 to 4.169	24.39 to 64.65	794	*Grayia spinosa*
11	4.169 to 5.144	64.65 to 171.4	1361	*Ambrosia dumosa, Krameria parvifolia, Ceratoides lanata, Ephedra nevadensis, Atriplex confertifolia*
12	5.144 to 6.119	171.4 to 456.5	999	*Larrea tridentata, Lycium andersonii*
13	6.119 to 7.094	456.5 to 1204.7	326	
14	7.094 to 8.069	1204.7 to 3193.9	43	
15	> 8.069	> 3193.9	—	

tata individuals into different ecotypes has not been demonstrated. The different ecotypes of *L. tridentata* might differ physiologically and consequently might be spatially separated. These two distinct life forms of *L. tridentata* are comparable in many respects to what is known in the Australian semiarid regions as Whip-stick and Bull Mallee, two distinctly different forms of *Eucalyptus oleoca* (Beadle 1948, El-Ghonemy 1967).

It can be concluded from the above study that the perennial species in the Rock Valley area are in a reasonably active state. The current rate of entrance of new plants into the ecosystem generally exceeds the rate of loss, with a consequent preponderance of younger individuals.

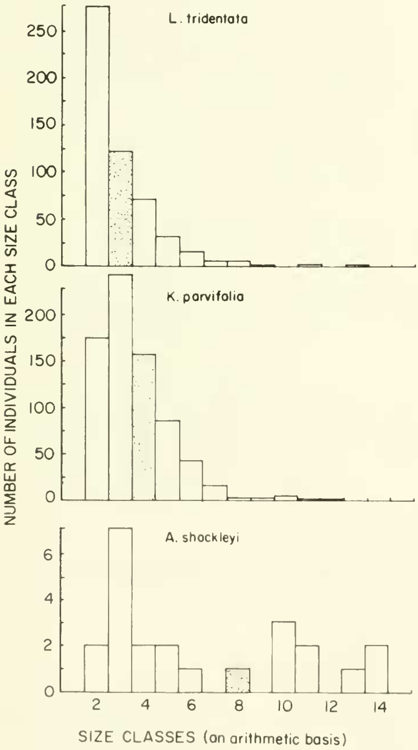

Fig. 2. Size distribution of three representative shrubs based on stem dry weight. Size-class intervals are 316 g for *Larrea tridentata*, 64.8 g for *Krameria parvifolia*, and 11.2 g for *Acamptopappus shockleyi*. Shaded bars represent size-classes that contain individuals that are close to the average weight for the species.

Table 3. Frequency distribution of individuals of different plant species in relation to the number included in the size class that includes individuals of the average weight for the species.

Species	Number of individuals in relation to their weight		
	<average	average	>average
(a) Species with J-shaped distribution curve			
Larrea tridentata	280	117	120
Ambrosia dumosa	632	314	237
Grayia spinosa	386	104	101
Ephedra nevadensis	232	58	97
Ceratoides lanata	163	7	64
Lycium pallidum	127	41	59
Atriplex confertifolia	20	4	13
(b) Species with unimodal, positively skewed distribution curve			
Krameria parvifolia	412	159	161
Lycium andersonii	165	87	99
(c) Species with asymmetric, polymodal distribution curve			
Acamptopappus shockleyi	14	1	8

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